IS 4493-4 (1982): Hollow Metallic Waveguides, Part 4: Flat Rigid Rectangular Waveguides [LITD 6: Wires, Cables, Waveguides and Accessories]

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IS : 4493 (Part IV) - 1982
(Reaffirmed 2003)

Indian Standard

SPECIFICATION FOR HOLLOW METALLIC WAVEGUIDES

PART IV FLAT RIGID RECTANGULAR WAVEGUIDES

UDC 621·372·822-46

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4 *September* 1983

Indian Standard

SPECIFICATION FOR HOLLOW METALLIC WAVEGUIDES

PART IV FLAT RIGID RECTANGULAR WAVEGUIDES

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(*Continued on page* 2)

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(*Continued from page* 1)

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SPECIFICATION FOR HOLLOW METALLIC WAVEGUIDES

PART IV FLAT RIGID RECTANGULAR WAVEGUIDES

0. FOREWORD

0.1 This Indian Standard (Part IV) was adopted by the Indian Standards Institution on 19 August 1982, after the draft finalized by the Microwave Components and Accessories Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard shall be used in conjunction with IS : 4493 (Part I)-1979*.

0.3 Different types of waveguides are being covered in a series of standards consisting of the following individual parts of IS : 4493:

Part I	General requirements and tests
Part II	Ordinary rigid rectangular waveguides
Part III	Medium flat rigid rectangular waveguides
Part IV	Flat rigid rectangular waveguides
Part V	Rigid rectangular waveguides with circular outside cross-section
Part VI	Rigid square waveguides
Part VII	Circular waveguides
Part VIII	Elliptical waveguides

0.4 While preparing this standard, assistance has been derived from the following:

a) IEC Pub 153-3 Hollow metallic waveguides: Part 3 Relevant specifications for flat rectangular waveguides. International Electrotechnical Commission.

b) JSS 53003 Detail specification for waveguides, rigid, flat rectangular. Ministry of Defence.

*Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part IV) specifies the requirements for flat rigid rectangular waveguides for use in electronic and telecommunication equipment.

2. TERMINOLOGY

2.1 For the purpose of this standard, the terms and definitions given in IS : 1885 (Part XIII/Sec 2)-1967† and IS : 4493 (Part I)-1979‡ shall apply.

3. CLIMATIC CATEGORIES

3.1 Provisions of **3** of IS : 4493 (Part I)-1979‡ shall apply.

4. MATERIAL CONSTRUCTION AND WORKMANSHIP

4.1 Provisions of **4** of IS : 4493 (Part I)-1979‡ shall apply.

5. DESIGNATION OF WAVEGUIDES

5.1 Provisions of **6** of IS : 4493 (Part I)-1979‡ shall apply.

6. MARKING

6.1 Provisions of **7** of IS : 4493 (Part I)-1979‡ shall apply.

7. PACKAGING

7.1 Provisions of **8** of IS : 4493 (Part I)-1979‡ shall apply.

8. DIMENSIONAL REQUIREMENTS

8.1 The outline and dimensions shall be in accordance with Fig. 1 and Table 1.

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary: Part XIII Telecommunication transmission lines and waveguides, Section 2 Microwave transmission lines and waveguides.

‡Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

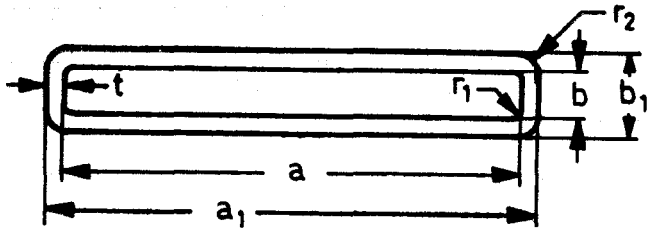

FIG. 1 OUTLINE DRAWING

9. ELECTRICAL CHARACTERISTICS

9.1 The electrical characteristics shall be as specified in Table 1.

10. CONDITIONS FOR TESTS

10.1 Provisions of **9.1** of IS : 4493 (Part I)-1979* shall apply.

11. CLASSIFICATION OF TESTS

11.1 Provisions of **9.2** of IS : 4493 (Part I)-1979* shall apply.

11.2 The schedule of type tests and requirements shall be in accordance with Table 2.

11.3 The schedule for acceptance tests shall be in accordance with Table 2 of IS : 4493 (Part I)-1979*.

12. TECHNICAL INFORMATION

12.1 Ratio Between Inside Width and Height — The standard ratio of inside width to inside height is in principle 8·33 : 1. For some types of waveguides given in this standard the ratio has not been observed because a different valuc of ratio was already in extensive use.

12.2 Deviation on Inside Width and Height — Deviations for the inside width and heights are in principle $\pm 1/1\,000$ of the internal width.

12.3 Frequency Range — The frequency range indicated in Table 1 is from 1·25 to 1·9 f_c (f_c = cut off frequency of dominant mode). For any particular type of application, the working frequency range may be smaller or greater than the frequency range given in the table.

*Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

12.4 Theoretical Power Rating — The values quoted are the theoretical breakdown values at a frequency 1·5 times the cut off frequency (assuming breakdown in air at NTP to occur at 30 000 V/cm). The figures quoted include a power safety factor of two as well as allowance for a voltage standing wave ratio of 2·0.

For other frequencies the values quoted should be multiplied by:

$$1 \cdot 34 \left[1 - (f_c / f)^2 \right]^{\frac{1}{2}}$$

12.5 Attenuation — The maximum attenuation shall not exceed 1·3 times the values calculated from formula (1) in **5.1** of IS : 4493 (Part I)-1979* at a frequency of 1·5 times the cut-off frequency. The values given in the table are for waveguides made of copper with standard resistivity $\rho_o = 1 \cdot 724\ 1 \cdot 10^{-8}$ ohm.metre.

*Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

TABLE 1 FLAT RIGID RECTANGULAR WAVEGUIDES

(*Clauses* 8.1, 9.1 *and* 12.3)

All dimensions in millimetres.

Type Designation	Frequency Range in GHz for Dominant Mode		Inside Cross-section					Outside Cross-Section			Radius of Corner r_2		Attenuation in dB/m			Peak Power Rating* MW
	From	To	Nominal Width a	Nominal Height b	Tolerance on Width and Height	Maximum Radius of Corner r_1	Nominal Wall Thickness t	Nominal Width a_1	Nominal Height b_1	Tolerance on Width and Height	Minimum	Maximum	Frequency in GHz	Theoretical Value	Maximum Value	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
F 22	1·72	2·61	109·22	13·100	±0·11	1·2	2·030	113·28	17·15	±0·22	1	1·5	2·06	0·030 18	0·039	1·42
F 26	2·17	3·30	86·36	10·400	±0·086	1·2	2·030	90·42	14·46	±0·17	1	1·5	2·61	0·043 93	0·056	0·91
F 32	2·60	3·95	72·14	8·600	±0·072	1·2	2·030	76·20	12·66	±0·14	1	1·5	3·12	0·056 76	0·074	0·61
F 40	3·22	4·90	58·17	7·000	±0·058	1·2	1·625	61·42	10·25	±0·12	0·8	1·3	3·87	0·077 65	0·101	0·39
F 45	3·68	5·60	50·80	16·942	±0·06	0·8	1·58	53·96	20·102	±0·15	0·8	1·3	4·32	0·042 95	0·056	—
F 48	3·94	5·99	47·55	5·700	±0·048	0·8	1·625	50·80	8·95	±0·095	0·8	1·3	4·73	0·105 07	0·137	0·27
F 58	4·64	7·05	40·39	5·000	±0·040	0·8	1·625	43·64	8·25	±0·081	0·8	1·3	5·57	0·130 66	0·170	0·20
F 70	5·38	8·17	34·85	5·000	±0·035	0·8	1·625	38·10	8·25	±0·070	0·8	1·3	6·46	0·143 9	0·181	0·17
F 84	6·57	9·99	28·499	5·000	±0·028	0·8	1·625	31·75	8·25	±0·057	0·8	1·3	7·89	0·165 1	0·215	0·14
F 100	8·20	12·5	22·860	5·000	±0·023	0·8	1·270	25·40	7·54	±0·046	0·65	1·15	9·84	0·193 1	0·251	—

NOTE — The values of attenuation given in the above mentioned table are for 100 percent copper. For other materials these values can be calculated using the formula given below [*see also* **9.3** of IS : 4493 (Part I)-1979†].

This formula does not apply for thinly plated surface:

$$\alpha = 2{\cdot}327\,3\left(\frac{\rho}{\rho_o}\right)^{\frac{1}{2}} \cdot \frac{1}{b\sqrt{a}} \cdot \frac{\left(\frac{f}{f_c}\right)^2 + \frac{2b}{a}}{\left(\frac{f}{f_c}\right)^{\frac{1}{2}}\left[\left(\frac{f}{f_c}\right)^2 - 1\right]^{\frac{1}{2}}} \text{ dB/m}$$

where

α = attenuation,

ρ = resistivity of inside non-magnetic wall metal,

ρ_o = resistivity of copper = $1{\cdot}724\,1 \times 10^{-8}$ ohm. metre,

a = inside width in millimetres,

b = inside height in millimetres,

f_c = cut-off frequency for H_{01} (TE_{01}) mode = $\frac{149{\cdot}9}{a}$ GHz, and

f = frequency at which the attenuation is to be calculated.

These values also can be evaluated by multiplying the values obtained for 100 percent copper by (ρ/ρ_o) where ρ_o is the resistivity of copper which is equal to $1{\cdot}724\,1 \times 10^{-8}$ ohm. metre and ρ is the resistivity of the material used. For guidance, multiplication factors for a few materials are given below:

$$\frac{0{\cdot}421\,[\,(f/f_c)^2 + 1\,]}{(f/f_c)^{\frac{1}{2}}[\,(f/f_c)^2 - 1\,]^{\frac{1}{2}}}$$

For other materials the figures quoted should be multiplied by:

Material	*Resistivity* ohm. metre $\times 10^{-8}$	*Multiplied by*
Silver 100 percent	1·56	0·98
Copper (ETP)‡	1·72	1·00
Silver (7½ percent copper)	1·80	1·06
Aluminium (100 percent)	2·83	1·30
Brass (90 percent copper)	3·90	1·55
Magnesium (100 percent)	4·60	1·68
Brass (70 percent copper)	6·50	2·00

*The values for this characteristic have been given for information only.

†Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

‡Pure high conductivity electrolytic tough pitch copper (ETP) conforming to IS : 191-1967 Specification for copper (*second revision*).

TABLE 2 TEST SCHEDULE AND REQUIREMENTS

(*Clause* 11.2 *and* 11.3)

Sl No.	Test	Clause Ref in IS : 4493 (Part I)-1979*	Condition of Test	Requirements
(1)	(2)	(3)	(4)	(5)
1. *All Samples*				
	a) Visual examination	**9.4.1**	—	The waveguides shall be visually examined and condition, design, workmanship, finish and marking shall be satisfactory. There shall be no burrs, cracks, pits or other irregularities of the surface. Both inner and outer surfaces shall have a clean bright appearance in accordance with current engineering practice and shall be free from oxidation.
	b) Dimensions	**9.4.2**	—	The dimensions and tolerance thereon shall conform to values given in Table 1 read with Fig. 1
	c) Bow			
	i) For component fabrication	**9.4.3.1**	—	Provisions of **9.4.3.1** of IS : 4493 (Part I)-1979* shall apply
	ii) For system applications	**9.4.3.2**	—	Provisions of **9.4.3.2** of IS : 4493 (Part I)-1979* shall apply
	d) Twist			
	i) For component fabrication	**9.4.4.1**	—	Provisions of **9.4.4.2** (a) of IS : 4493 (Part I)-1979* shall apply
	ii) For system application	**9.4.4.1**	—	Provisions of **9.4.4.2** (b) of IS : 4493 (Part I)-1979* shall apply
	e) Squareness of cut	**9.4.5**	—	The squareness of cut of the waveguide shall be measured. The departure from squareness of the end of any waveguide shall not exceed 0·25 mm for waveguides up to 16 mm maximum inside waveguide dimension inclusive and 0·4 mm per 25 mm for waveguides over 16 mm maximum inside waveguide dimension
2. *First Group*				
	a) Surface roughness	**9.4.8**	Corner radius may not be included in the measurement	The surface roughness shall be measured as described in Appendix B of IS : 4493 (Part I)-1979*. The average interior surface roughness of the waveguide shall not exceed the value shown in Table 3 of IS : 4493 (Part I)-1979*
	b) Scratches	**9.4.6**	—	Provision of **9.4.6** of IS : 4493 (Part I)-1979* shall apply
3. *Second Group*				
	a) Internal stresses	**9.4.9**	The waveguide tube shall be cut by means of a saw. The cutting process should be carefully controlled so as to avoid distortion arising from the cutting; and the use of a fine high-speed saw is recommended.	After cutting, the cross-sectional dimensions of the tube shall still be within the specified tolerances

*Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

(*Continued*)

TABLE 2 TEST SCHEDULE AND REQUIREMENTS — *Contd*

Sl No.	Test	Clause Ref in IS : 4493 (Part I)-1979*	Condition of Test	Requirements
(1)	(2)	(3)	(4)	(5)
	b) Hardness	**9.4.7**	The waveguide tube shall be tested for hardness at both ends around the periphery	The average of a minimum of six readings shall be within the tolerances stated below: The waveguide shall comply with the following diamond pyramid hardness numbers, using a 10 kg load: a) Copper 80 to 130 b) Brass 70/30 120 to 170 c) Brass 90/10 100 to 150 d) Silver 85 to 140 e) Aluminium As specified in the contract f) Lined As for (a), (b) or (c) above as relevant g) Copper electroformed 90 to 240 h) Magnesium As specified in the contract
4.	*Third Group* a) Attenuation	**9.3.1** and **5.1**	Measured at 1·5 times the cut off frequency H_{01} (TE_{01}) mode	As specified in Table 1
5.	*Fourth Group* a) Dry heat	**9.5.1** and **3.1**	After recovery under standard atmospheric conditions, the following measurements shall be made	—
	i) Visual examination	—	—	The waveguides shall be visually examined and condition, design, workmanship, finish and markings shall be satisfactory. There shall be no burrs, cracks, pits or other irregularities of the surface. Both inner and outer surfaces shall have a clean bright appearance in accordance with current engineering practice and shall be free from oxidation
	ii) Bow	**9.4.3**	—	The requirements shall be within the limits specified in the standard.
	iii) Rectangularity of cross section	**9.4.2.1** (e)	—	The requirements shall be within the limits specified in **9.4.2.1** (e) of IS : 4493 (Part I)-1979*
	iv) Twist	**9.4.4.1**	—	The requirements shall be within the limits specified in the standard
	b) Cold	**9.5.2** and **3.1**	—	After recovery under standard atmospheric conditions measurements and requirements specified as in dry heat test shall be applicable
	c) Rapid change of temperature	**9.5.3** and **3.1**	Not less than 30 minutes	After recovery under standard atmospheric conditions, measurements and requirements specified as in dry heat test shall be applicable

NOTE 1 — For waveguides used in aviation, the climatic category with dry heat temperature as +100°C; cold temperature as −65°C and rapid change of temperature from −65°C to +100°C would be applicable.

NOTE 2 — For waveguides used on ground equipment (fixed or mobile), the climatic category with dry heat temperature as +100°C; cold temperature as −40°C and rapid change of temperature from −40°C to +100°C would be applicable.

NOTE 3 — For waveguides used for general purpose in laboratory, the climatic category with dry heat temperature as +85°C; cold temperature as −10°C and rapid change of temperature from −10°C to +85°C would be applicable.

*Specification for hollow metallic waveguides: Part I General requirements and tests (*first revision*).

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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